CHAPTER C.2
FORMULATION OF THE LCA ECOSYSTEM MODEL

Robert R. Twilley[1]

John Barras [2]

[1] *Center for Ecology and Environmental Technology, University of Louisiana at Lafayette*
[2]*, USGS, National Wetlands Research Center*

2.1 Introduction

The Louisiana Coastal Area (LCA) Ecosystem Model was developed to establish a process to evaluate the various alternatives proposed to rehabilitate coastal Louisiana utilizing the concepts of restoration science described in chapter C.1. An intense effort was initiated to develop ecosystem models to support the planning and evaluation processes of the LCA Comprehensive Ecosystem Restoration Plan. This chapter presents the formation of the LCA Modeling Team, describes the development of this LCA Ecosystem Model, and provides an overview of the database framework development. Detailed descriptions of specific model components are discussed in subsequent chapters.

2.2 LCA Modeling Team Organization

A group of experts was assembled to develop and operate the LCA Ecosystem Model. The modeling effort consisted of several teams and workgroups (Table C.2-1) from various Federal, state and academic organizations. Workshops and numerous works sessions were held to flush out the framework and details of the model components. A dedicated web site was used established to deposit and transmit data among team members.

The modeling effort presented was accomplished between August 2002 and September 2003. A general conceptual model workshop, attended by more than 100 scientists and resource managers initiated the challenge in developing a tool to evaluate alternatives of the restoration plan. The LCA framework committee was organized to define the modeling process and organizational structure of the modeling teams and work groups for each of the five modules (Fig.C.2-1) The work groups included experts that contributed to both simulation and desktop modeling approaches.

The Goals and Endpoints workgroup was responsible for defining the principles and targets of the restoration approach. Subgroups of technical experts were assembled in a workshop to develop algorithms for each of the five modules of the LCA Ecosystem Model (Fig. C.2-1). More that 38 scientists, engineers and resource managers participated on one of the five modules of the LCA Ecosystem Model, providing expertise to either the simulation or desktop approach, including a group that developed a module on ecosystem benefit protocols (Table C.2-1). The groups were organized to produce deliverables that would allow for the evaluation of alternatives as described in Figure C.1-10. These workgroups were responsible for integrating expertise among university and agency scientists and interface closely with LCA study managers to develop appropriate modeling scenarios. This group also developed scientifically rigorous ways to describe and quantify remaining uncertainty (chapter C.13).

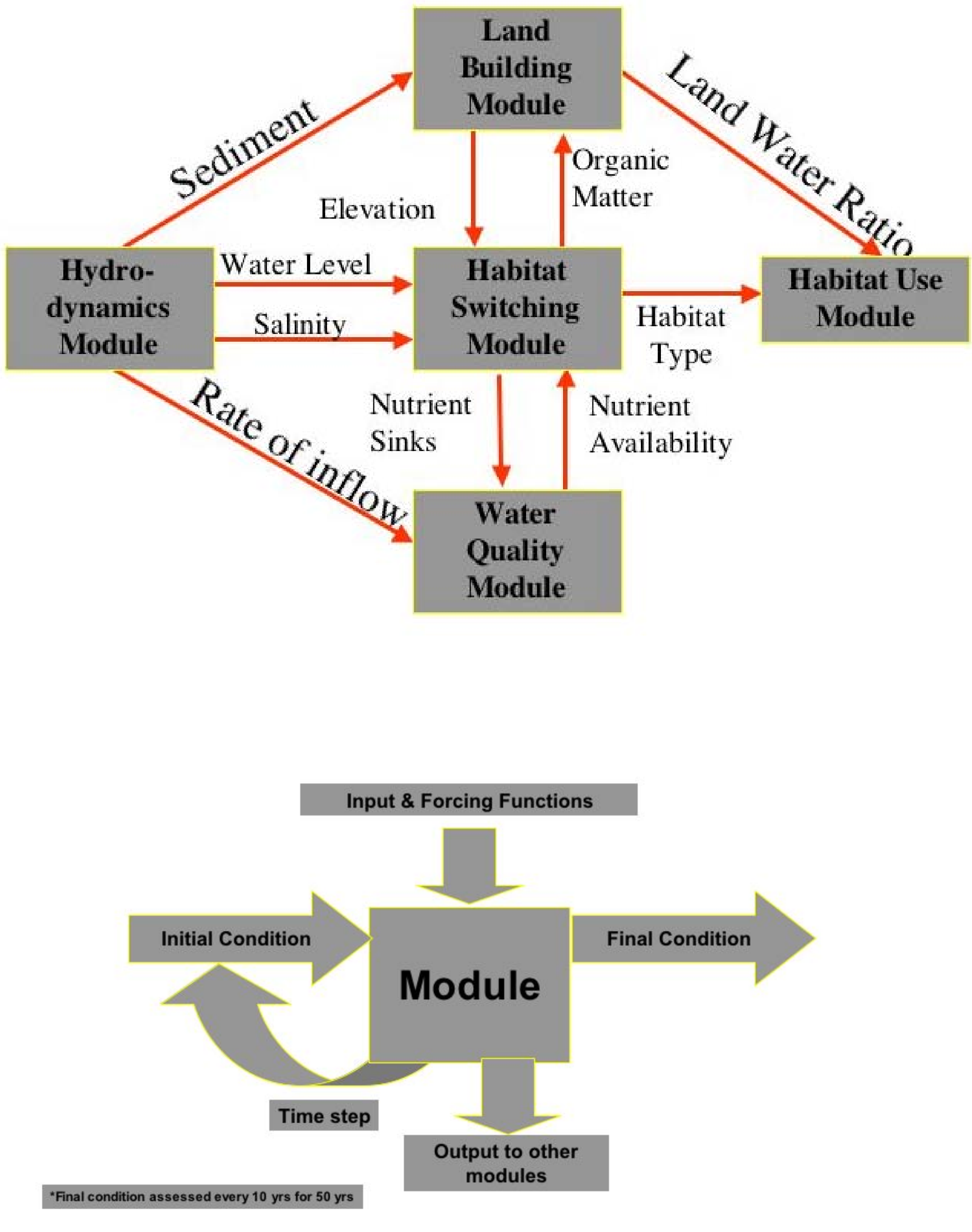

Figure C.2-1 Linkage of Different Modules used in Desktop and Simulation Models

Table C.2-1 List of participants in the LCA Ecosystem Model program.

GOALS AND ENDPOINTS TEAM			
Chair	Constance	Troy	US Army Corps of Engineers
Chair	Porthouse	Jon	LA Department of Natural Resources
	Beville	Shelley	LA Department of Natural Resources
	Bodin	Gerald	US Fish and Wildlife Service
	Buras	Honora	LA Department of Natural Resources
	Davis	Mark	Coalition to Restore Louisiana
	Etheridge	Beverly	US Environmental Protection Agency
	Ettinger	John	US Environmental Protection Agency
	Finley	Heather	LA Department of Wildlife and Fisheries
	Grouchy	Catherine	US Fish and Wildlife Service
	Haase	Bren	US Department of Commerce, NOAA
	Klein	Bill	US Army Corps of Engineers
	Llewellyn	Dan	LA Department of Natural Resources
	Merino	Joy	US Department of Commerce, NOAA
	Reed	Denise	University of New Orleans
	Steyer	Cindy	USDA Natural Resource Conservation Service
	Steyer	Greg	USGS National Wetlands Research Center
	Twilley	Robert	University of Louisiana at Lafayette
	Visser	Jenneke	Louisiana State University

LCA ECOSYSTEM MODEL TEAMS – Robert R. Twilley			
SIMULATION MODELING TEAM			
Chair	Clairain	Buddy	US Army Corps of Engineers
Chair	Twilley	Robert	University of Louisiana at Lafayette
	Aravamuthan	Vibhas	Louisiana State University
	Day	John	Louisiana State University
	Justic	Debravko	Louisiana State University
	Kemp	Paul	Louisiana State University
	Mashriqui	Hassan	Louisiana State University
	McCorquodale	Alex	University of New Orleans
	Georgiou	Ioannis	University of New Orleans
	Meselhe	Ehab	University of Louisiana at Lafayette
	Nuttle	Bill	Consultant
	Reyes	Enrique	University of New Orleans
	Rivera	Victor	University of Louisiana at Lafayette
	Suhayda	Joe	Louisiana State University

Table C.2-1 Continued

DESKTOP MODELING TEAM			
Chair	Steyer	Greg	USGS National Wetlands Research Center
Chair	Visser	Jenneke	Louisiana State University
	Hydrodynamics Workgroup		
Chair	Nuttle	Bill	Consultant
Chair	Swenson	Eric	Louisiana State University
	Aravamuthan	Vibhas	Louisiana State University
	Mashriqui	Hassan	Louisiana State University
	Meselhe	Ehab	University of Louisiana at Lafayette
	Stutts	Vann	US Army Corps of Engineers
	Barre	Clyde	Us Army Corps of Engineers
	Wetland Nourishment Workgroup		
Chair	Visser	Jenneke	Louisiana State University
	Callaway	John	University of San Francisco
	Reed	Denise	University of New Orleans
	Steyer	Greg	USGS National Wetlands Research Center
	Suhayda	Joe	Louisiana State University
	Swenson	Erick	Louisiana State University
	Habitat Switching Workgroup		
Chair	Visser	Jenneke	Louisiana State University
Chair	Steyer	Greg	USGS National Wetlands Research Center
	Shaffer	Gary	Southeastern Louisiana University
	Hester	Mark	University of New Orleans
	Höppner[4]	Susanne	Louisiana State University
	Keddy	Paul	Southeastern Louisiana University
	Linscombe	Greg	LA Department of Wildlife and Fisheries
	Mendelssohn	Irving	Louisiana State University
	Reyes	Enrique	University of New Orleans
	Sasser	Charles	Louisiana State University
	Swarzenski	Christopher	USGS, Water Resources Division
	Habitat Use Workgrouop		
Chair	Foret	John	US Department of Commerce, NOAA
Chair	Nyman	John A.	Louisiana State University
	Baird	B.	
	Cowan	James	Louisiana State University
	Rozas	Lawrence	US Department of Commerce, NOAA
	Rose	Kenneth	Louisiana State University
	Baltz	Donald	Louisiana State University

Table C.2-1 Continued

	Water Quality Workgroup		
Chair	Rivera-Monroy	Victor	University of Louisiana at Lafayette
Chair	Teague	Kenneth	US Environmental Protection Agency
	Barko	John	US Army Corps of Engineers
	Justic	Debravko	Louisiana State University
	McCorquodale	Alex	University of New Orleans
	Swarzenski	Chris	USGS Water Resources Division
	Nestler	John	US Army Corps of Engineers
	Dortch	Mark	US Army Corps of Engineers
	Twilley	Robert	University of Louisiana at Lafayette
	Benefits Workgroup		
Chair	Hawes	Sue	US Army Corps of Engineers
Chair	Reed	Denise	University of New Orleans
	Carloss	Mike	USDA Natural Resource Conservation Service
	Clairain	Buddy	US Army Corps of Engineers
	Ettinger	John	US Environmental Protection Agency
	Grouchy	Cathy	US Fish and Wildlife Service
	Haase	Bren	US Department of Commerce, NOAA
	Llewellyn	Dan	LA Department of Natural Resources
	Roy	Kevin	US Fish and Wildlife Service
	Sasser	Charles	Louisiana State University
	Steyer	Gregory	USGS National Wetlands Research Center
	Spatial Framework Workgroup		
	Barras	John	USGS National Wetlands Research Center
	Suir	Glenn	USGS National Wetlands Research Center
	Padgett	Clint	USGS National Wetlands Research Center
	Whittinton	Arin	Johnson Controls World Services

2.3 LCA Model Development

The size of the study area and the schedule restricted the formulation of a comprehensive LCA Ecosystem Model. As a result of these restrictions, a hybrid of simulation and desktop modeling was utilized in this study (Figure C.2-2).

2.3.1 Existing Models

A total of 26 hydrodynamic and water quality models were reviewed by Day et al (2000) to build a classification framework for coastal rehabilitation. Of these, at least 15 different models have been used one time or another to examine coastal problems in Louisiana. This overview describes different approaches and solutions proposed by the science and engineering community to coastal management issues. A major conclusion of this review is that modeling efforts have failed to integrate available environmental information and utilize it under some forecasting capabilities. An exception to this tendency is The Oceanography Division of the Naval Research Laboratory with their rapid model implementation of NRL Ocean Modeling, Assimilation, Demonstration System (Harding et al. 1999) and NOAA Coastal Forecast System [Curt Mason, NOAA National Ocean Service (NOS) Senior Scientist Office, Silver Spring, MD]. The report by Day et al. recommended the development of a more consistent spatial framework in landscape models that can account for the spatial and time scales required to develop restoration alternatives. The report also recommended that landscape models integrate biological and species-specific modeling efforts. This requires incorporation of trophic level dynamics at population level using bioenergetic models. Such models will have to link biophysical parameters to animal behavior, at the community level, to predict and evaluate "essential fish habitat" dynamics. Such models also need to include important feedback processes, at the landscape level, of trophic links to other parts of the ecosystem. Restoration efforts require the ability of ecosystem models to forecasts ecosystem response of physical, chemical and biological endpoints.

2.3.2 Modeling Tools

The LCA Ecosystem Model was constructed by evaluating existing modeling tools for coastal Louisiana to develop a system that could evaluate alternatives recommended as components of LCA Comprehensive Ecosystem Restoration Plan. Modeling tools had to be available immediately, in order to meet the timeline of the LCA planning phase, that could link geophysical, geomorphological and ecological responses of coastal ecosystems to variety of measures that made up the restoration alternatives. Four types of modeling/ evaluation tools where utilized.

1) Numerical modeling represents the highest level of sophistication in ecological modeling where clearly defined assumptions of ecological mechanisms are linked to geophysical processes. These models can be used to simulate the endpoints of engineering alternatives.

2) Less sophisticated hydrodynamic models, such as box models, have the advantage of predicting endpoints of salinity, hydroperiod, and possibly sediment distribution over longer time scales, albeit with more coarse spatial resolution. Endpoints of these models can be linked to ecological conceptual models to estimate ecosystem response.

3) Monitoring and feasibility studies (empirical information) were used to statistically estimate ecosystem response to various levels of river resources. Two strategic sources of information for such empirical relationships include delta building processes occurring at the mouth of Wax Lake outlet and Atchafalaya River. In addition, there exist both monitoring and experimental observations of ecosystem response in Breton Sound in response to specific discharge volumes from the Caernarvon diversion.

4) Finally, if none of these three tools are available to forecast ecological response to river resources, then expert scientific opinion was solicited. However, even the latter technique needs to be based on clearly defined conceptual models that link environmental drivers to ecosystem response.

The first and second types of models described above are referred to as ‘simulation modeling’ in the LCA Ecosystem Model. Models that use the third and fourth approach, that relies less on computational analysis and more on empirical relationships, are referred to as ‘desktop modeling’. The distinction is that products from simulation models are based more on processes than statistical assessments of relationships as in the desktop models.

2.3.3 Simulation modeling.

The experience in Florida and other large restoration programs dictates that the core of alternative analysis and selection be based upon predictive, deterministic, process-based simulation models. The time constraints, as well as the size and heterogeneous nature of the vast LCA study area, prevented the reliance upon any single modeling approach. Available models were reviewed and a subset selected for use in the LCA Ecosystem Model. Existing estuarine and landscape simulation models were simultaneously employed for different subprovinces, with overlap in crucial zones of interest. These models ranged from (a) hydrodynamic (TABS, POM and MIKE 11) models with differing capacities for constituent transport to (b) hydrodynamic models with constituent transport and landscape evolution (CELSS). Each of these models met a minimal requirement of resolving wind and tide-induced circulation, and salinity in two dimensions at a resolution of 1 km^2 or higher. The hydrodynamic models utilized for the LCA study effort are described in Chapters C3-C6.

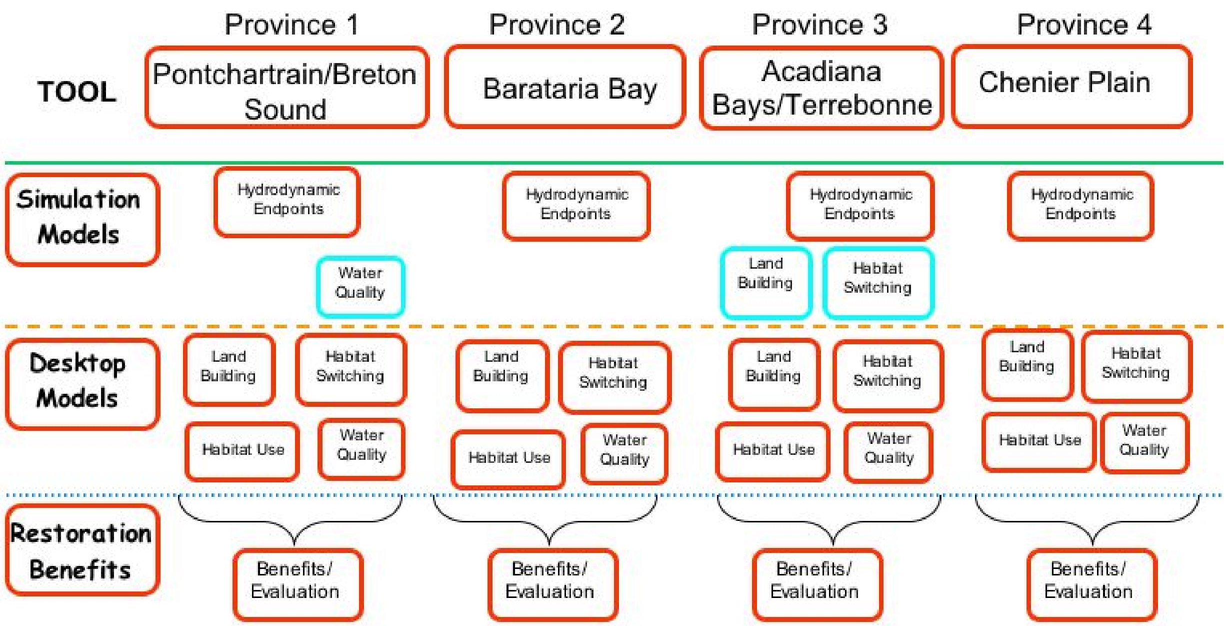

Figure C.2-2. Hybrid of desktop and simulation modeling tools for benefit evaluation.

Hydrodynamic simulation models have been developed in some form for most of the subprovinces and they were used to generate hydrodynamic endpoints. In Figure C.2-2 hydrodynamic models are listed in the simulation model category for all four provinces of LCA. However, province-wide hydrodynamic models were only available in subprovinces 1 and 2. In subprovinces 3 and 4 hydrodynamic models only partially covered the provinces; and desktop models had to be used in the remainder of these subprovinces. The LCA Ecosystem Model was designed to evaluate 32 subprovince alternatives of the ecosystem restoration plan.. There was insufficient time for the simulation models in the hydrodynamic module to evaluate all 32 alternatives. Specific alternatives were evaluated using simulation models and produced the first phase of hydrodynamic endpoints (Table C.2.2). Based on these results, hydrodynamic endpoints for the remaining alternatives were determined using desktop modeling techniques.

Endpoints from the hydrodynamic modules, from either simulation or desktop techniques, were used to drive the other four modules: land building, habitat switching, habitat use, and water quality (Figure C.2-1). Most of these modules were generated using desktop modeling techniques (Figure C.2-2). Each of these modules is interdependent on the other, and required information generated by one module to be utilized by another module (Figure C.2-2). This process required that the assumptions used by both the simulation and desktop models be consistent and that the endpoints determined by each module be compatible with the input needs of the other modules. Desktop models had to be capable of using the five core modules in any of the four subprovince areas. Most of the endpoints generated for the ecosystem benefits analysis were the product of hybrid simulations of both simulation and desktop model output.

Table C.2-1 Description of the alternatives simulated with numerical models.

Subprovince 1	Subprovince 2	Subprovince 3	Subprovince 4
B01	B01/with 0.5 Davis pond	B01	B01
R01	B02/No Davis Pond	R01	E01
M02	E01	R02	E02
E02	E02	R03	E03
		M01	M01
			M02
			M03

B = Future without or base Condition
R= Reduce land loss rate by half
M= Maintain land loss at current rate
E = Increase land gain

2.3.4 Desktop modeling.

Another approach to modeling geophysical, geomorphological and ecological processes is the use of more coarse scale ‘desktop’ statistical approach. For example, these types of models include ‘box model’ approaches (Chapter C7) to hydrodynamic and water quality variables, as well as ‘spreadsheet’ methods to estimate ecological responses to restoration alternatives (Chapters C8-C11). Desktop models also translated model output into ecosystem benefits that fit LCA goals and objectives

A general module was utilized as a template to develop conceptual desktop models for land building, habitat switching, habitat use, and water quality (Figure C.2-1). Critical forcing functions, outputs, measurement units of outputs, and time steps were determined for each desktop models These determinations were based on reported relationships in peer reviewed literature, gray literature, and reports; statistical analysis of existing data; and best professional judgment. All assumptions were explicitly stated and referenced and compared with those assumptions utilized by the simulation models. Model runs were designed around producing output from the modules for a 50 year period at 10 year intervals.

As described above, most of the endpoints of were generated based on desktop model techniques for during the evaluation of the LCA ecosystem in response to the different alternatives. Simulation model techniques were only available Only hydrodynamic models in some of the coastal province could be generated using simulation model techniques. An exception is subprovince 3 where a landscape simulation model included hydrodynamic, land building, and habitat switching modules. In this region, only habitat use and water quality desktop modules had to be used. Yet, this model did not cover all of subprovince 3 requiring desktop models be used in those areas (and thus their inclusion under subprovince 3 in Figure C.2-2). The endpoints from the modules were developed into algorithms that were used to quantify ecosystem benefits (chapter C.12).

The framework for this LCA Ecosystem Model is designed to change and evolve as additional information is provided and as individual modules are integrated. A goal of the LCA Ecosystem Model is to use simulation models for all five modules across all four subprovinces. This will require an intensive effort to develop more processed-based modeling techniques across the entire coastal landscape that can integrate geophysical processes with behavior of higher trophic levels. In addition, the LCA modeling had to develop methods to extrapolate long-term habitat succession (50 years and greater) from relatively short hydrodynamic model runs (less than 1 year).

2.4 Database Framework Development

2.4.1 Spatial Framework Development

The LCA Ecosystem Model used a spatial framework to provide key information to build the landscape base for model development. This framework would serve to define the model domain and provide a mechanism to facilitate spatial data exchange into and out of the various modules. The LCA Ecosystem Model was developed using Geographic Information System (GIS) technology to integrate information flow among five modules (Fig.C.2-3). A spatially explicit platform was developed that could input and process information for cells at a scale of 247 acres (1 km^2) units referred to as LCA cells (Fig. C.2-5).

The spatial extent of the LCA cells was identified using the 2050 Mapping Units (reference from old 2050 report). A polygon grid was created, based on the spatial extent of the 2050 mapping units, containing the 38,557 LCA cells using ESRI ArcInfo GIS software (Table C.2-2).

Each LCA cell's center coordinates and upper left corner coordinates were assigned Universal Transverse Mercator (UTM) grid and Geographic (decimal degrees) coordinate pairs to facilitate cell spatial referencing. A unique numerical id was assigned to each cell to facilitate linkage of attribute (non-spatial) descriptive information to the cell, including spatial display of model outputs as thematic maps. The resultant cell grid allowed the LCA Desktop Modeling Team (DMT) to exchange and integrate both spatial and non-spatial information at multiple resolutions (scales) using an explicit spatial reference covering the entire study area. Data was readily exchanged between scientists, GIS specialists, and agency personnel using a common reference system that facilitated data integration, analysis, and output. The cell’s unique numerical id facilitated data transfer between DMT members using a variety of data formats (spreadsheets, ASCII tables from numerical models/statistical analysis software, and various spatial formats). The LCA Grid’s design’s flexibility allowed DMT members to work on their various modeling components without mandating the use of a particular software suite, but required spatially referencing their respective outputs to the Grid.

Table C.2-2 LCA Spatial Framework Parameters

Parameter	Value
Projection	UTM Zone 15
Datum	NAD 83
Units	Meters
Upper Left X Coordinate	409627.188
Upper Left Y Coordinate	3375164.250
Lower Right X Coordinate	910627.188
Lower Right Y Coordinate	3197164.250

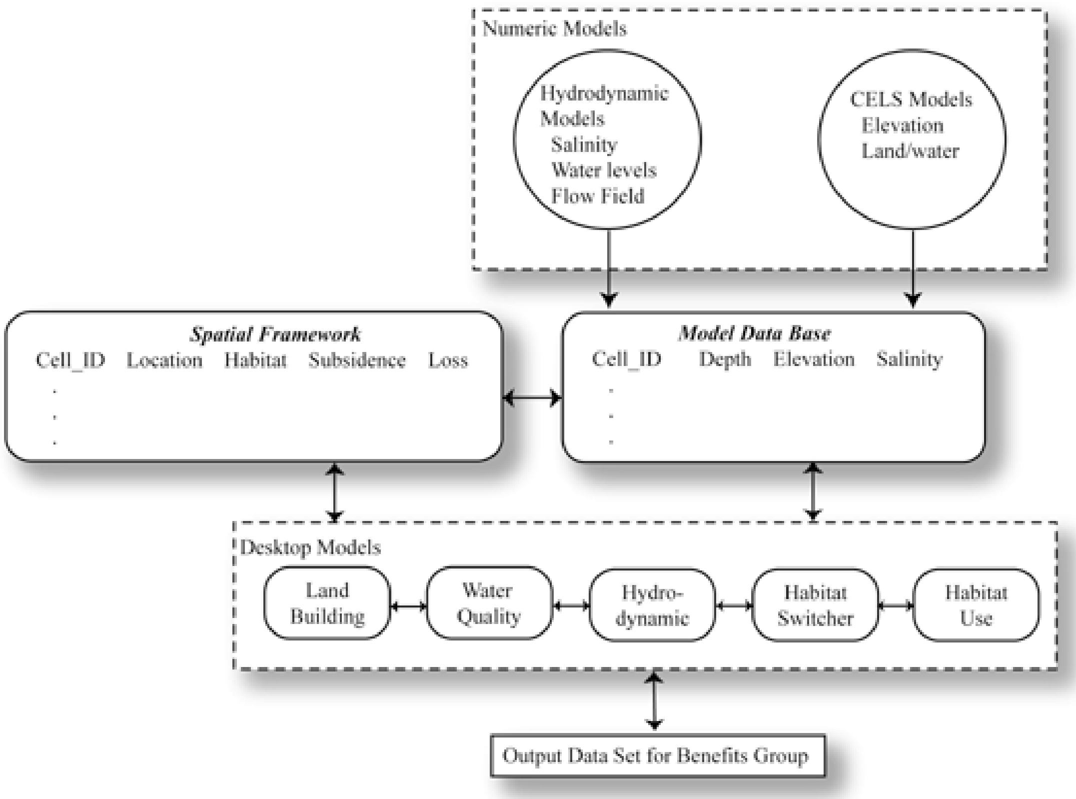

Figure C.2-3 Schematic of how information was processed in the LCA Ecosystem Model using the GIS data base.

2.4.2 Referencing of Key Spatial Datasets to the LCA Grid

Several key spatial datasets were identified by the DMT for inclusion in the LCA Desktop Model and were integrated into the Grid using a variety of spatial analytical procedures, requiring storage of the resultant data sets in both raster and vector formats. The grid attribute or non-spatial descriptive information for each of these key spatial datasets was then exported to an excel spreadsheet format for distribution to the DMT members as input information for the various models.

Table C.2-2 Spatial Analysis Terms

Term	Definition
vector	A basic spatial data storage format consisting of points, lines, and polygons.
point	A discrete location that represents a coordinate pair in space
line	A set of coordinates that represents a linear shape in space
polygon	A set of coordinates that enclose a specified area in space
raster	A basic spatial data storage format consisting of a regular set of cells or pixels covering an area. Each cell is assigned a unique value based on it's position within the grid. Spatial resolution is implicit. Digital images are stored in a raster format.
attribute	Descriptive or tabular information describing spatial features. All non–spatial DMT descriptive information are considered attributes. Ex. Productivity by cell, average annual salinity by cell, or predominate marsh type by cell.
overlay	Term used to describe the spatial merging of two or more vector or raster data sets to create a new dataset containing the spatial information common to both data sets. The new data sets' boundary will coincide with the minimum shared area between the source datasets unless other wise specified. Ex. The overlay of marsh type zones with a land and water base data set will result in a data set spatially depicting marsh types with the current land and water base
identity	A more sophisticated type of vector overlay function that allows the selection of specific attribute data associated with the source data sets. Ex. Assign basin, subprovince, and mapping unit information from a source polygon data set to the LCA Grid using an identity function. The output is a spatial dataset containing the selected attribute information by cell.
summary	A raster summary function used to compare to data sets. The source data set is spatially compared to the index data set to generate an ASCII report that creates basic statistics and area summaries based on coincidence of the source and index data sets. Ex. Summarize marsh types or elevation values by LCA Cell.
attribute	Descriptive information describing spatial features. All non –spatial DMT descriptive information are considered attributes. Ex. Productivity by cell or predominate marsh type by cell.
resolution	The minimum spatial resolution accurately depicted in a spatial data set. Ex. the raster 2000 land and water data set has a minimum resolution of 25 meters. The LCA Grid can depict model output at a minimum spatial resolution of 1 km^2.

Table C.2-3 Key LCA Spatial Datasets

Name	Type	Description
LCA Cell Grid	vector polygon	Data set containing 43138 LCA 1 km^2 cells
LCA Cell Index	vector polygon	Data set resulting from identity overlay of` LCA Cell Grid with a polygon data set containing Coast 2050 mapping units, hydrologic basin boundaries, and subprovince boundaries.
LCA Desktop Habitat Base	raster	Habitat base used to summarize land/water ratios and predominate habitat types by LCA Cell. The base was created using multiple raster overlay functions to combine the most current and readily available habitat base for the LCA domain. The base consists of 1) the 2000 coast wide land and water mosaic used to determine the historical trends for the LCA (Barras et al, 2003, 2) the 2001 marsh type map created for the Louisiana Dept. of Wildlife and Fisheries and the USGS NWRC (Linscombe et al.,

		unpublished) and 3) The 1993 GAP data compiled by the USGS NWRC (Hartley, et al. 2000). A summary function was used to calculate desktop habitat composition for each LCA Cell.
LCA Subsidence Information	vector polygon	Coast wide subsidence information based on information developed by Kulp (2000). The original information was converted from a DXF (digital exchange CAD format) figure depicting interpolated subsidence contours to a vector polygon format. Some of the contours required extension to close the polygons and were approved by Dr Kulp. An identity function was used to assign subsidence rates by LCA Cell. Kulp, M.A., 2000)
LCA Hydrologic Box Information	vector polygon	Consists of hydrologic box information developed for the Desktop Modeling effort. The hydrologic box segments were assigned to LCA cell using an identity function.
LCA Predicted Land Loss and Gain	Vector raster	The LCA trend polygon data set was used to develop a reclassified polygon data set identifying trend polygons by nominal, moderate, and extreme loss rates. The trend rates were assigned by LCA Cell using an identify function
LCA Scenario Infrastructure	Vector point line polygon	Consists of province specific data sets required to incorporate various LCA infrastructure components within the LCA Cell Grid for model input. Infrastructure components include marsh creation areas, diversions, LCA Cell proximity to diversions, barrier island/shoreline creation, and shoreline protection/stabilization. The infrastructure information was assigned by LCA Cell using an identify function
Subprovince 2 Elevation Data	Raster	An attempt was made to develop average desktop habitat elevations by LCA Cell within subprovince 2 using available LIDAR data. Approximately 105 digital elevation model (DEM) files based on LIDAR data covering the southern half of subprovince 2 were merged and converted to raster contour files. Average elevations by desktop habitat type were summarized for LCA cells coinciding the elevation data using the summary function. The desktop habitat elevation information should be interpreted with caution due to missing elevation information or “holes” within the source DEM data.

Key Spatial Model Output		
LCA Model Output	Vector Polygon	These data sets consist of the various model output scenarios that could be linked back to the LCA Cell Grid as cell attributes, using each cell’s unique id, to spatially display model output at cell resolution on a coast wide or individual subprovinces basis. Incorporation of the model output with the LCA Cell Grid facilitates rapid creation of maps depicting model output and facilitates use of model output for other applications requiring spatial analysis such as socio-economic assessments

The final data base consisted of 38,557 cells (Table C.2-5). A hybrid of habitat information was merged into a LCA Desktop Habitat data base that covered the LCA model domain with information at 247 acres (1 km^2) based on 82ft x 82ft (25 m x25 m) resolution of map information from the original sources (Fig. C.2-4, Fig. C.2-5). Marsh types in the data based were identified from a 2001 Chabreck/Linscomb marsh type polygon data set that is based on manual interpolation of vegetative transects consisting of over 8000 sampled points. The Marsh Type data set is used by the Louisiana Department of Wildlife and Fisheries (LDWF) to identify suitable alligator habit.

The marsh type data was overlaid with 2000 land and water data (Barras et al. 2003) to provide an interim marsh type data set based on a current land/water interface. An offshoot of the overlay process was the identification of smaller water bodies occurring within the marsh type zones. Selected land cover classes (swamp, bottomland hardwood, and developed lands) from 1993 GAP data (Hartley et al. 2000) were then overlaid with the interim data set to create the habitat based for the LCA Ecosystem Model. This base was used to describe habitat types associated with wetland areas and the water landscape for the entire domain of the LCA Ecosystem Model.

Table C.2-4 2001 Linscombe Marsh Type Classes

Classification	Data Interpretation
Fresh Marsh	Interpolated fresh marsh zone
Intermediate Marsh	Interpolated intermediate marsh zone
Brackish Marsh	Interpolated brackish marsh zone
Saline Marsh	Interpolated saline marsh zone
Swamp	Interpolated Swamp Zone
Other	Non-swamp and non-wetlands occurring within the marsh type area
Water	Freshwater lakes (generally > 100 acres) and open bays considered non-alligator habitat. The 2001 marsh type data set does not contain a high resolution land/water interface. Small ponds and streams are not imbedded in the data set.

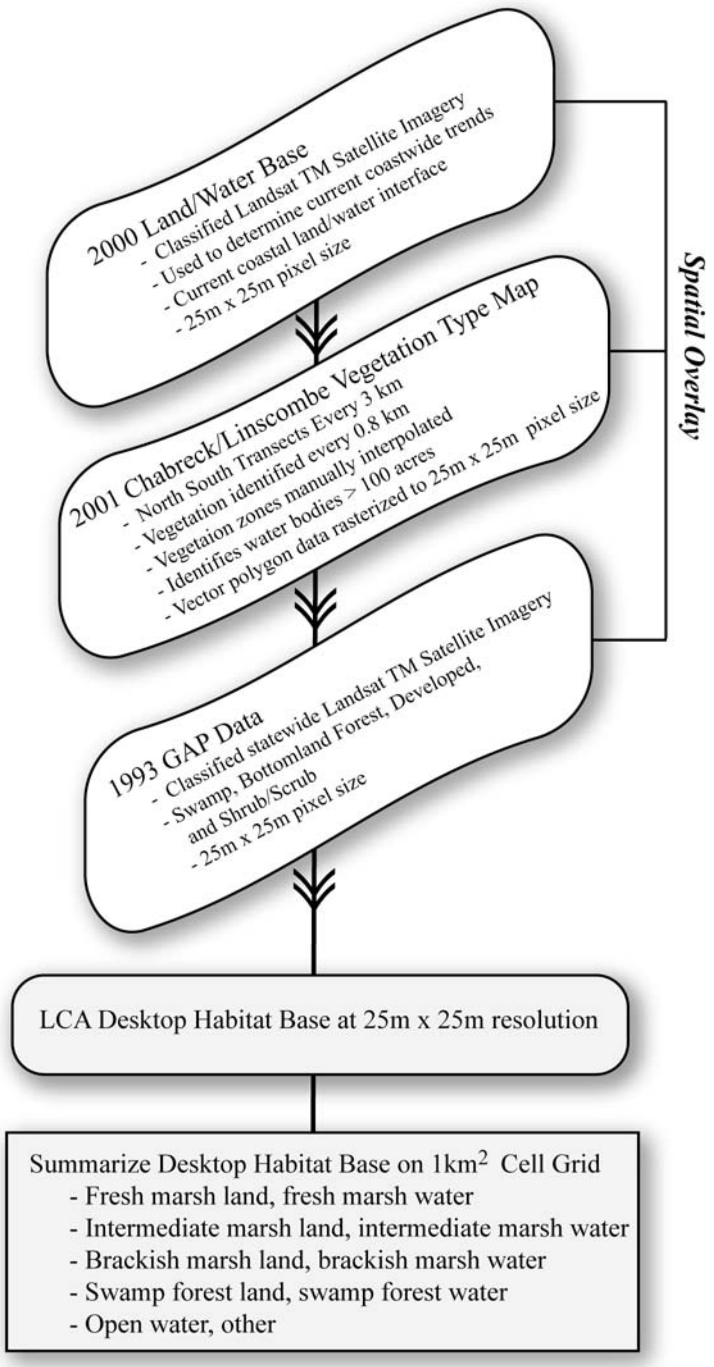

Figure C.2-4 Information used to generate the LCA desktop model habitat data base.

The habitat types identified in each LCA cell (1 km^2 or 250 acres) included fresh march, intermediate marsh, brackish marsh, salt marsh, wetland forest, wetland shrub, non-wetland, non-wetland-water, wetland-water, water-water, and total wetland. A cell was identified as a ‘water cell’ if it contained more that 100 acres of water-water. All other cells were identified as non-water and identified as one of the vegetation types depending on ranking in area. For example, a cell with > 100 acres is considered water. A cell with < 100 acres is a land cell and classified as one of the vegetation types depending of which has the highest area. Each land cell location in the model domain is identified by latitude and longitude of the central point of the cell. A program determined the distance of each land cell from the nearest water cell.

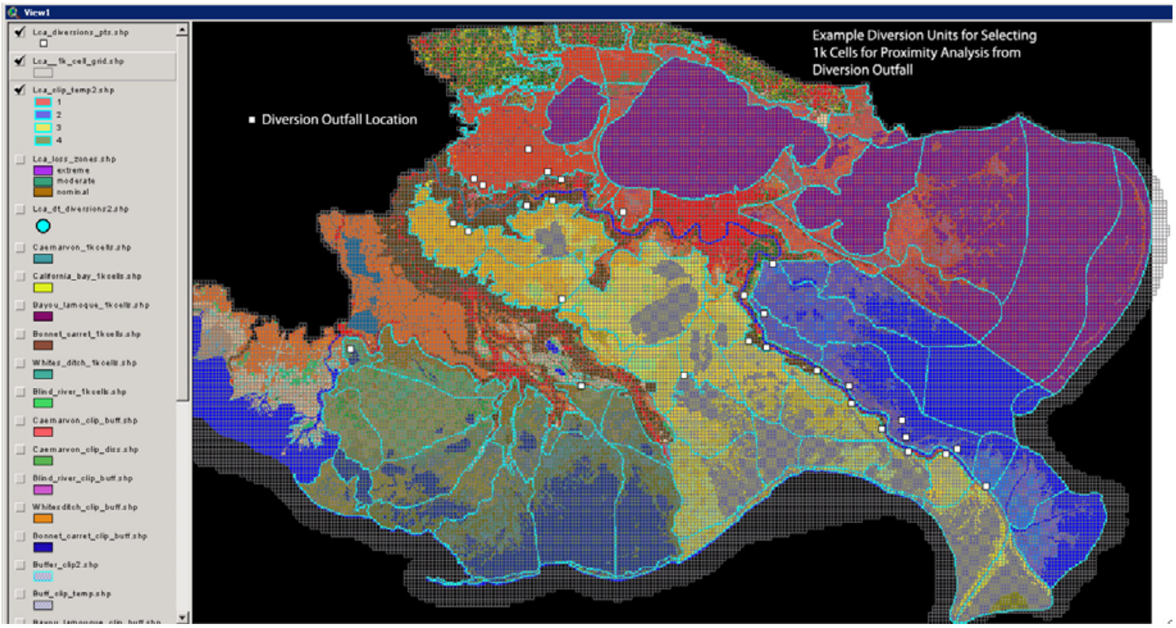

Figure C.2-5 Construction of spatially explicit landscape with over 38,000 one square kilometer (250 acres) cells.

Table C.2-5. Number of 1 km^2 (250 acres) cells in the four subprovinces of the LCA Ecosystem Model.

Subprovince	Number of Cells
Subprovince 1	14,746
Subprovince 2	7,288
Subprovince 3	10.987
Subprovince 4	5.536
Total	38,557

The data base was used to compile additional information for each LCA cell. Subsidence rates were interpolated from contours developed by Kulp (2000) based on rates from specific locations throughout the model domain. Unregistered source subsidence contours from Kulp were registered and converted to a vector polygon format to define subsidence zones. These zones were overlaid with the LCA Cells using an identify function to determine subsidence rates by cell. Land loss rates were also applied to each LCA cell based on the analysis by Barras et al. (2003). The topography of the LCA Ecosystem Model domain was one of the most difficult data to compile. Information for segments of the model domain was compiled from several different sources of data to provide a coast-wide topographic description. The elevation of water cells was taken from the bathymetric information of the hydrodynamic simulation models. An attempt was to include LIDAR data for subprovince 2 into the data base; but the noise in these data prevented the utility of this source of information for the model domain.

2.4.3 Linking Channel Attributes to Wetland Regions

Each of the four LCA subprovinces were partitioned into LCA cells as described above. Additionally, each subprovince was partitioned into boxes or segments to link information from hydrodynamic models to the landscape models (Figure C.2-6). Boxes were constructed to fit either previous conventions of box construction, such as Wiseman and Swenson (1989) for subprovinces 2 and 3; or in those areas where box models have not been constructed, vegetation maps were used to distinguish zones of salinity regimes in coastal landscape. Special consideration had to be applied to subprovince 4, given the large amount of landscape that is under water management. Boxes in this region were constructed with consultation with the Ecological Services office of U.S. Fish and Wildlife Service in Lafayette, LA.

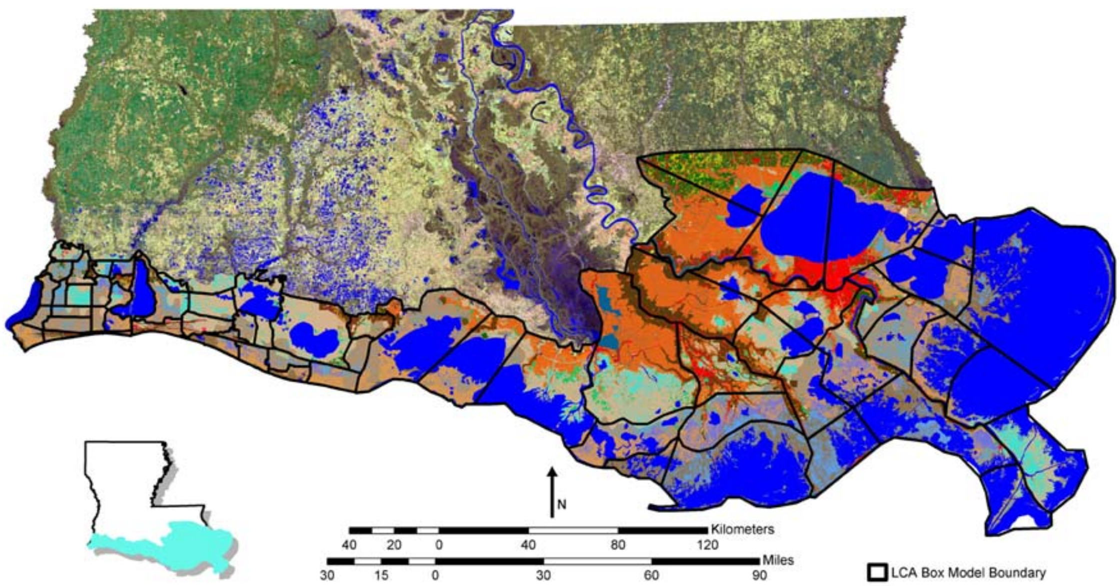

Figure C.2-6 Boxes used to summarize information from hydrodynamic simulation models.

Linking the changes in the physical characteristics of Louisiana estuaries to restoration alternatives is critical step in predicting geomorphic and ecologic responses. Hydrodynamic attributes generated by the simulation models used by the other modules included water salinity, depth, elevation, and flow. Water temperatures were not variables in all the hydrologic simulation tools. All the hydrodynamic information was specific for nodes (locations) in channels and bays of the model domain; and this information had to be extrapolated to wetlands. We used the landscape boxes (segments) as the spatial unit to summarize hydrodynamic information across the LCA Ecosystem Model domain. Given the large uncertainties of forecasting the influence of geophysical processes on specific attributes of hydrodynamics such as salinity, water levels, and water velocities, the boxes would provide the coarse spatial scale interpretation that would minimize the error predicted at micro-scale output. The advantages of using box model analysis of hydrodynamics in restoration projects are described in chapter C.7 of this report. The first procedure to interpret hydrodynamic information from nodes of hydrodynamic models was to classify nodes with specific LCA cells. Programs were constructed that placed nodes from the various hydrodynamic models within LCA water cells. If there was more than one node per LCA water cell, then attributes of those respective nodes were averaged to calculate one value for that water cell. All the attributes of water cells in a specific box were averaged per month to calculate hydrodynamic parameters for each box. This information was then assigned to each of the land cells that had been classified into respective boxes. With this information, hydrodynamic attributes for a group of nodes for channels in a specific box could be applied to the land (wetland) cells.

Subprovince 1 is an example of the process of transferring results from the hydrodynamic models to wetland cells of the LCA model domain (Figure C.2-7). The upper left panel shows the location of various river diversions and the associated 10 km contours of each input of freshwater to the floodplain. A simulation model (see chapter C.3) of the hydrodynamics for a particular alternative provided information on the attributes of salinity, water level, and water flow at a number of nodes in the subprovince (lower left panel). Attributes at specific nodes of the water cells in the channels of the landscape (upper right panel) are averaged for each month and then applied to wetland cells in the respective box. A major assumption here is that all the land cells of each box will respond to the results of nodes in respective boxes.

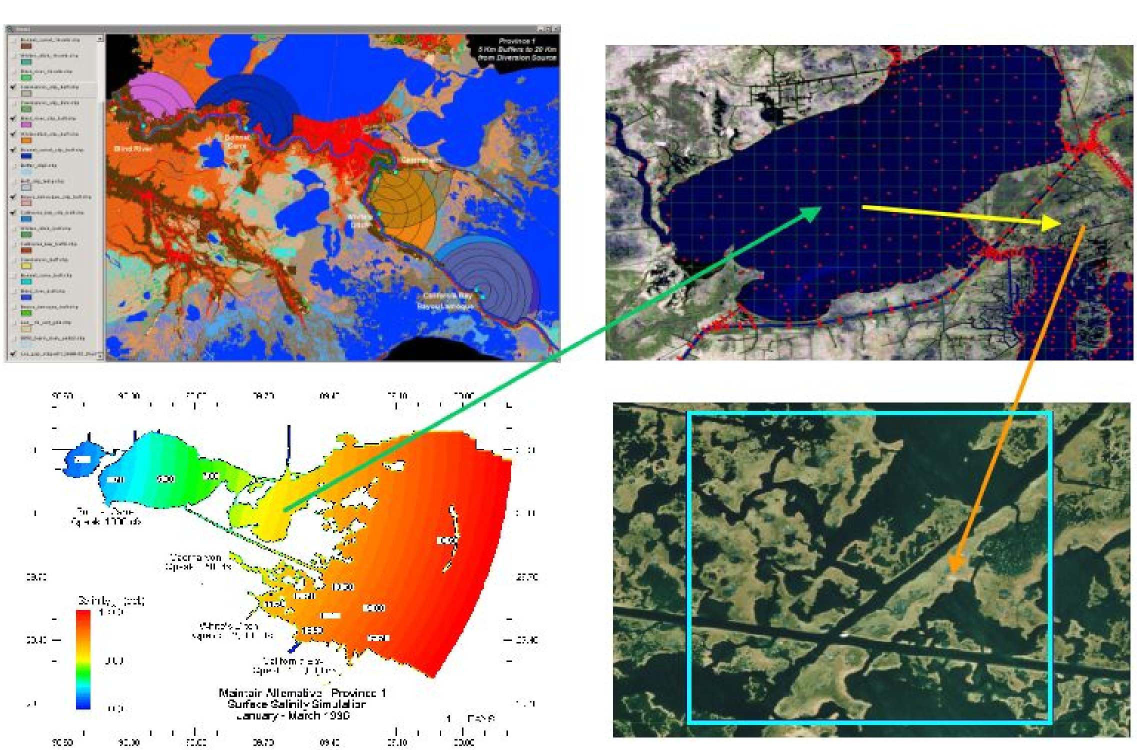

Figure C.2-7 Example of how information from the hydrologic simulations, at specific nodes in the channels of the coastal waters, is transferred to coastal wetlands at 1 km^2 resolution.

Information of hydrodynamic attributes for each month for each LCA cell was passed to the desktop modules for further analysis (Fig. C.2-3). The hydrodynamic simulation models were able to evaluate 2-4 alternatives for each province. Results of these simulations were used to interpolate salinities and hydrodynamic attributes for the other alternatives for each subprovince. These hydrodynamic data, from both simulation and desktop analysis, was transferred to the other four modules (land building, habitat switching, habitat use, water quality) to evaluate ecosystem response as described in chapters C.3 to C.6. Output from each of the modules was processed by SAS and results were generated into spreadsheets and maps for each LCA cell. Output was evaluated by the LCA collocation team by access to the technical area of the LCA website. The web site contained a 'comment' section; and several meetings were held from March to May 2002 to calibrate module results with field and professional observations. Adjustments were made to either model or parameter information and new results posted on the LCA web site. During a three-month period, there were at times eight versions of a subprovince that were evaluated until most of the major 'bugs' could be eliminated and model results fit simple calibrations. Limitations and uncertainty of each module are described in chapter C.13. In addition, a preliminary sensitivity analysis was performed on the modules described in chapter C.14.